FER Performance of LDPC Based MIMO-OFDM System in Shallow Water Communication Using 4-QAM

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Abstract— Various researches has been carried out to explore the effective ways of communication inside the water between the submarines or to collect information from sensors inside the water. To make it more reliable this paper proposed a methodology which utilizes the LDPC codes with the multiple input multiple output (MIMO) orthogonal frequency division multiplexing(OFDM) with BPSK and QAM modulation schemes. The wireless communication inside water is quite similar to outside of the water of this a little effect of rarer versus denser factor affects the communication, density of water is high and the transmission speed is generally 1500 m/sec. The FER performance is better compared to previous work and having optimum FER is $10^{-4.6}$.

Key words: Shallow Water Communication, LDPC, MIMO-OFDM, QAM and BPSK

I. INTRODUCTION

The ability to communicate effectively underwater has numerous applications for marine researchers, oceanographers, marine commercial operators, off-shore oil industry and defense organizations. The same as electromagnetic waves cannot propagate over long distances in sea water; acoustics provides the most obvious choice of energy propagation to enable underwater communications. Underwater acoustic (UWA) communications has been a difficult problem due to unique channel characteristics such as the fading, extended multipath and the refractive properties of the sound channel [1, 2]. Attempts at adapting communication techniques developed for other channels have yielded successful implementations in vertical deep water channels, but have had limited success in shallow water channels [2-4]. One of the most challenging UWA communication channel is believed to be the medium range. In channels common in humid coastal regions as Singapore waters. This warm shallow water acoustic (WSWA) channel presents two key features .– extensive time-varying multipath [5] and high levels of non-Gaussian ambient noise due to snapping shrimp [5-7] both of which limit the performance of traditional communication techniques. Several commercial and research acoustic modems are available for use in deep waters and some are available for use in shallow waters. Although the shallow water modems demonstrate good performance in some shallow water environments, many of them perform poorly in Singapore waters. The research presented here seeks to better understand the warm shallow water environment in Singapore and develop suitable channel propagation and noise models. It also aims to develop a communication scheme that would provide robust performance in such environments. Although directional receivers and spatially distributed transmitters and receivers can significantly improve communication performance, we target our efforts on the development of communication systems with a single omni-directional transducer. Such single-input-single-output (SISO) communication systems tend to yield relatively small, portable and low-cost implementations which are important in many underwater applications.

The UWA channel is band-limited and reverberant. Until the late 1970's, communication systems had no means of mitigating the distortion introduced by such channels [8]. With the advent of digital communications and parallel developments in severely fading radio channels, some level of channel compensation and explicit error correction became possible. Since then UWA communications has seen a steady improvement in data rate and reliability. The initial improvements were based on incoherent modulation techniques such as frequency shift keying (FSK) due to their robustness.

$$\text{FER} = 1-(1-\text{BER})^4 \text{ (in this case)}$$

$$\text{FER}=\frac{\text{Number of error frames}}{\textit{Total number of transmitted fremes}} \times 100$$

Correlation between E_sN_o and E_bN_o (SNR)

$$E_s/N_o = E_b/N_o\ (\text{dB}) + 10\log_{10}(k)$$

Where k is the number of information per symbol
E_s/N_o = ratio of symbol energy to noise power spectral density
And E_b/N_o = ratio of bit energy to spectral power density

In the early 1980's it was believed that phase coherent modulation techniques would not work in UWA channels. However, interest in phase coherent systems due to their higher bandwidth efficiency led to a large number of publications in the 1990's. Powerful receiver algorithms coupled with decision feedback equalizers (DFE) and second-order phase-locked-loop (PLL) enabled phase coherent algorithms to achieve rates of up to 10 kbps in a medium range shallow UWA channel [9;10]. Later, data rates of 20 kbps have been reported in a very shallow UWA channel at Woods Hole harbor [11] while rates of nearly 15 kbps have been reported in the Baltic Sea [12].

II. PROPOSED METHODOLOGY

In the recent years MIMO has drawn significant attention of researchers in the field of wireless communication. Multipath fading is main bottleneck in increasing the data rate and reliability of transfer of information over wireless channel. Channel coding Techniques which are used to improve reliability is insufficient to meet the requirements of modern multimedia communications.

Wireless communication using multiple-input multiple-output (MIMO) systems enables increased spectral efficiency for a given total transmit power. That increased the capacity is achieved by introducing additional spatial channels that are exploited by using space-time coding. The environmental factors affect MIMO capacity. Those factors include channel complexity, interference, and channel estimation error. That was shown that, if multiple antennas are used at transmitter and or receiver can improve data rate and reliability.

In Fig. 2.1 the block diagram of the proposed approach has been given. The major blocks are modulation of data using BPSK and QAM followed by Serial to parallel conversion of modulated signal. Now the signal has been coded with LDPC and modulated by orthogonal frequency division multiplexing (OFDM) and before transmission of signal cyclic prefix are added. FER means combination or group of bits that is called frames.

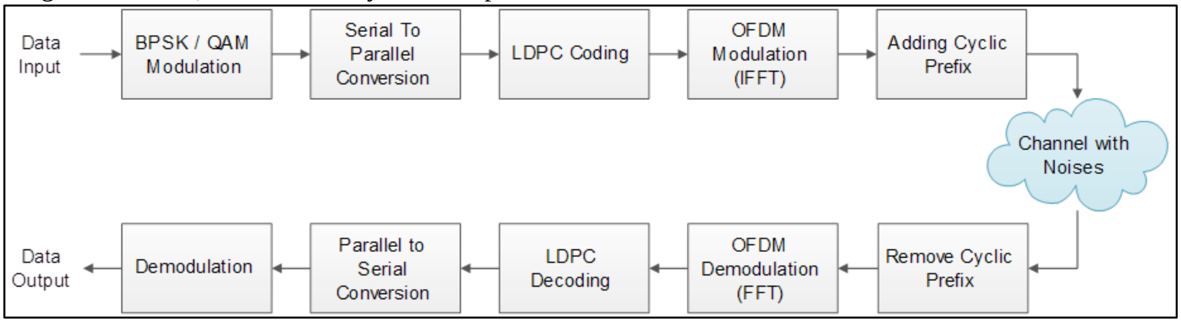

Fig. 1: Block diagram of the proposed shallow water communication system

During transmission through channel signal is encountered with the noises and reached at the receiver. AWGN is generally a basic noise model to imitate the effect of many random processes that take place in nature. On the receiver the reverse method of transmitter is taken place and the data will be taken out.

The above describe block diagram of the proposed methodology is then implemented on simulation tool and the its step by step flow is shown in the given Fig. 2.2.

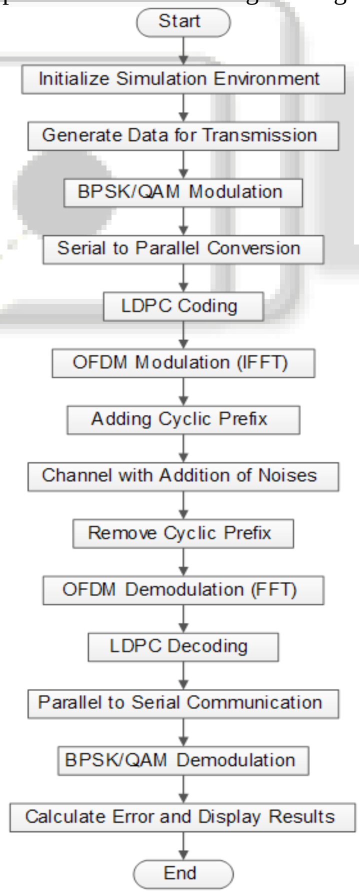

Fig. 2: Flow chart of the simulation algorithm of proposed shallow water communication system

The execution of the simulation algorithm is explained step by step which are as follows:

(1) Start simulation
(2) Create simulation environment using variable initialization
(3) Generate random data for transmission over system
(4) Modulate data with BPSK and QPSK Modulation
(5) Convert signal from serial to parallel
(6) Code signal with LDPC coding
(7) Perform OFDM Modulation i.e. IFFT
(8) Add cyclic prefix
(9) Transmit channel and add noises
(10) Remove cyclic prefix
(11) Perform OFDM demodulation that is FFT
(12) Decoding with LDPC coding
(13) Convert parallel data to serial
(14) Demodulate data with BPSK/QAM modulation
(15) Calculate Error Rate
(16) Compare and display results
(17) End of Simulation

III. SIMULATION RESULTS

The proposed underwater acoustic communication is simulated in the previous section and the results of the analyzed system are shown in this section. The results are calculated as Frame Error Rate (FER) vs Signal to Noise Ratio(SNR) for various combinations of data. The first result (see Fig. 3.1) graph shows FER vs SNR graph for 128 bit FFT size of OFDM system by applying MIMO-OFDM system and the modulated with BPSK and QAM techniques.

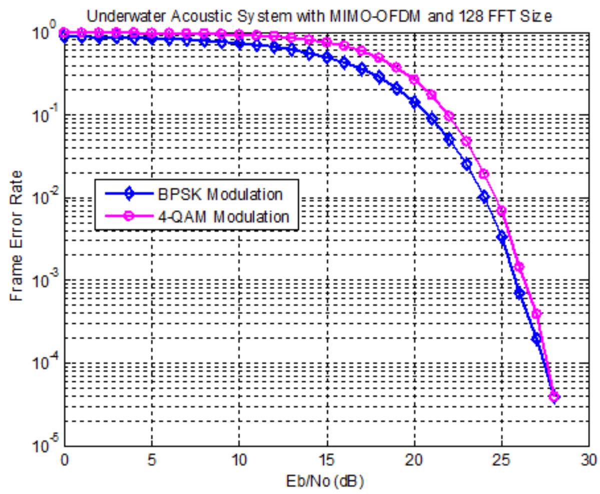

Fig. 3: FER vs SNR curve of shallow water communication with MIMO-OFDM System using 128-Bit FFT Size

From the results it can be says that the shallow water communication system is better work with the MIMO-OFDM technology and the BPSK modulation and using LDPC coding technique than QAM counterpart.

The second result (see Fig. 3.2) graph shows FER vs SNR graph for 256 bit FFT size of OFDM system by applying MIMO-OFDM system and the modulated with BPSK and QAM techniques. From the results it can be noticed that the shallow water communication system is better work with the MIMO-OFDM technology and the BPSK modulation and using LDPC coding technique than QAM counterpart.

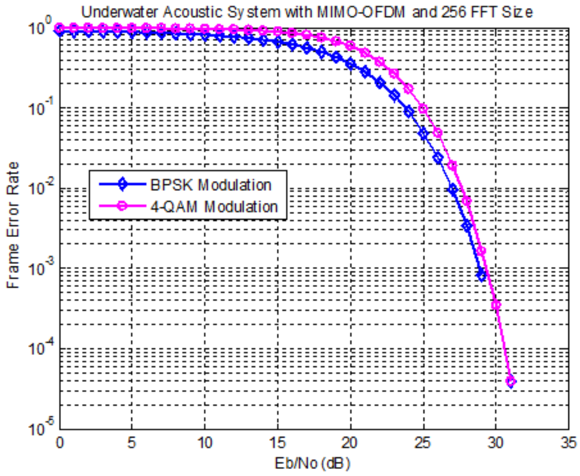

Fig. 4: FER vs SNR curve of shallow water communication with MIMO-OFDM System using 256-Bit FFT Size

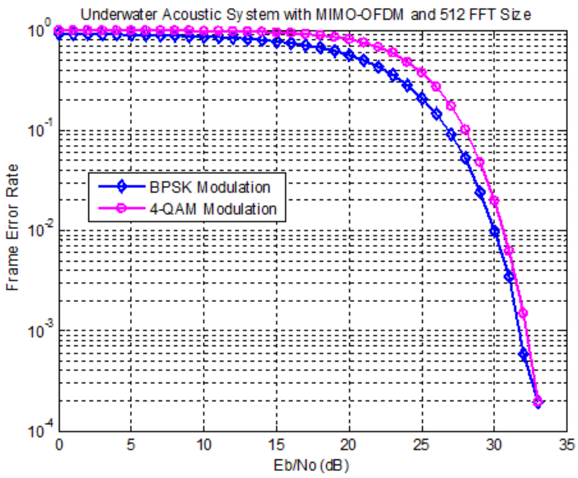

Fig. 5: FER vs SNR curve of shallow water communication with MIMO-OFDM System using 512-Bit FFT Size

The third result (see Fig. 3.3) graph shows FER vs SNR graph for 512 bit FFT size of OFDM system by applying MIMO-OFDM system and the modulated with BPSK and QAM techniques. From the results it can be noticed that the shallow water communication system is better work with the MIMO-OFDM technology and the 4-QAM modulation and using LDPC coding technique than BPSK counterpart.

The fourth result (see Fig. 3.4) graph shows FER vs SNR graph for 1024 bit FFT size of OFDM system by applying MIMO-OFDM system and the modulated with BPSK and QAM techniques. From the results it can be says that the shallow water communication system is better work with the MIMO-OFDM technology and the BPSK modulation and using LDPC coding technique than 4-QAM counterpart.

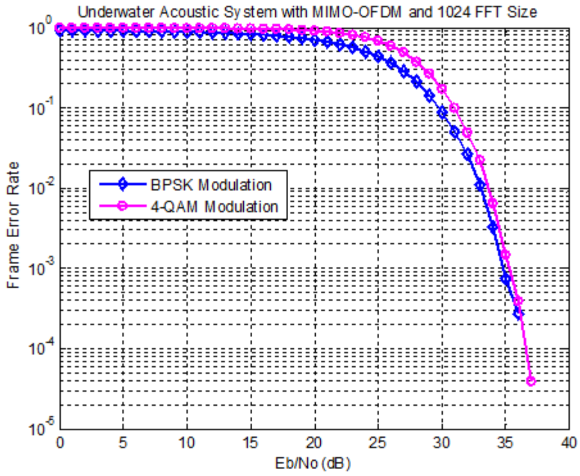

Fig. 6: FER vs SNR curve of shallow water communication with MIMO-OFDM System using 1024-Bit FFT Size

IV. CONCLUSION AND FUTURE SCOPE

The simulation results of the proposed communication model is calculated and shown in the previous section. From the results we can say that the system with the 4-QAM modulation and having higher FFT size gives better results than the lower FFT size and BPSK modulation. In the upcoming technologies better transmitters and the efficient modulation technique will help to achieve better results than current performance.

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